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(54) **RADIANT HEATER FOR PRINT MEDIA**

(75) Inventors: **Roger G. Leighton**, Hilton, NY (US); **Michael F. Leo**, Penfield, NY (US); **Nicholas P. Kladias**, Fresh Meadows, NY (US); **James Edward Williams**, Penfield, NY (US)

(73) Assignee: **Xerox Corporation**, Norwalk, CT (US)

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B41J 2/01 (2006.01)

(52) **U.S. Cl.**
USPC **347/102**

(58) **Field of Classification Search**
CPC B41J 11/002
USPC 347/16, 101, 102, 104; 219/390, 219/405
See application file for complete search history.

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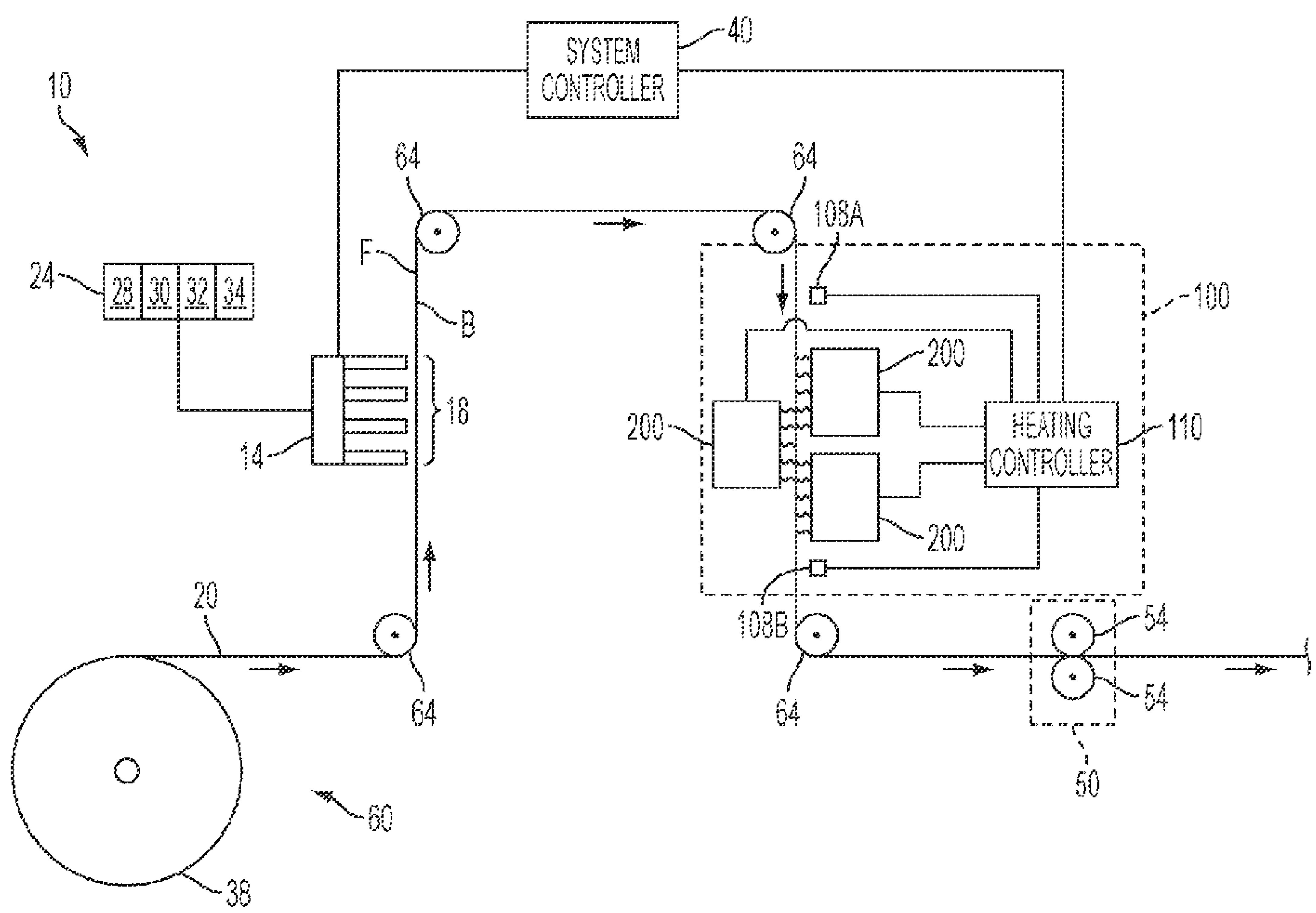
Primary Examiner — An Do

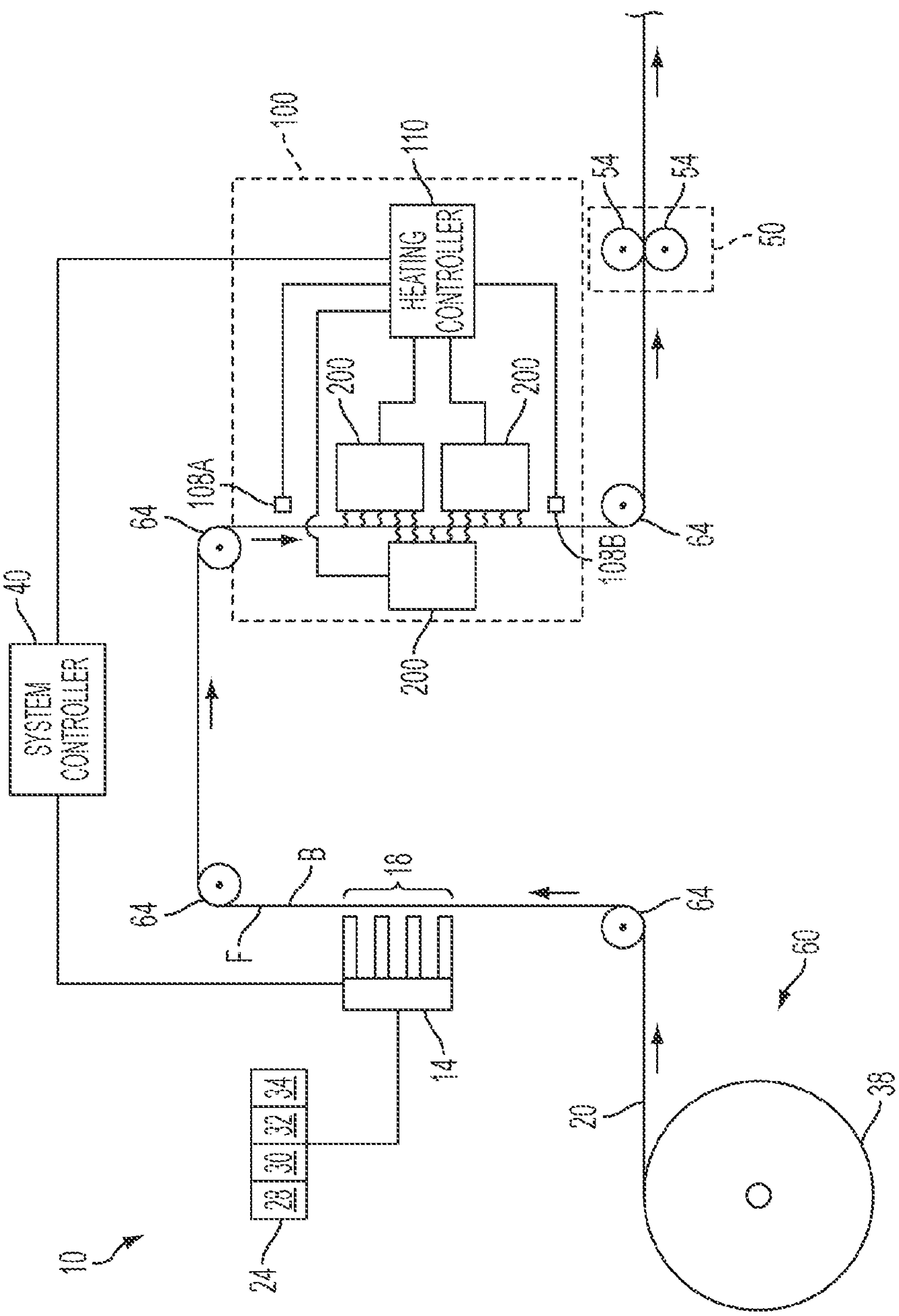
(74) *Attorney, Agent, or Firm* — Maginot, Moore & Beck, LLP

(57) **ABSTRACT**

A heater panel is configured to heat a print medium in a printer. The heater panel includes electrical conductors that form a plurality of heating zones to emit radiant energy toward the print medium. Heating zones that correspond to edges of the print medium emit radiant energy with a greater power density than heating zones that correspond to central portions of the print medium. The heater panel has a plurality of angled positions to vary the view factor for high gain control.

20 Claims, 7 Drawing Sheets





SYSTEM CONTROLLER
HEATING CONTROLLER
10
14
16
20
24
28
30
32
34
38
40
50
54
60
64
100
108A
108B
110
200
B
F

FIG. 1

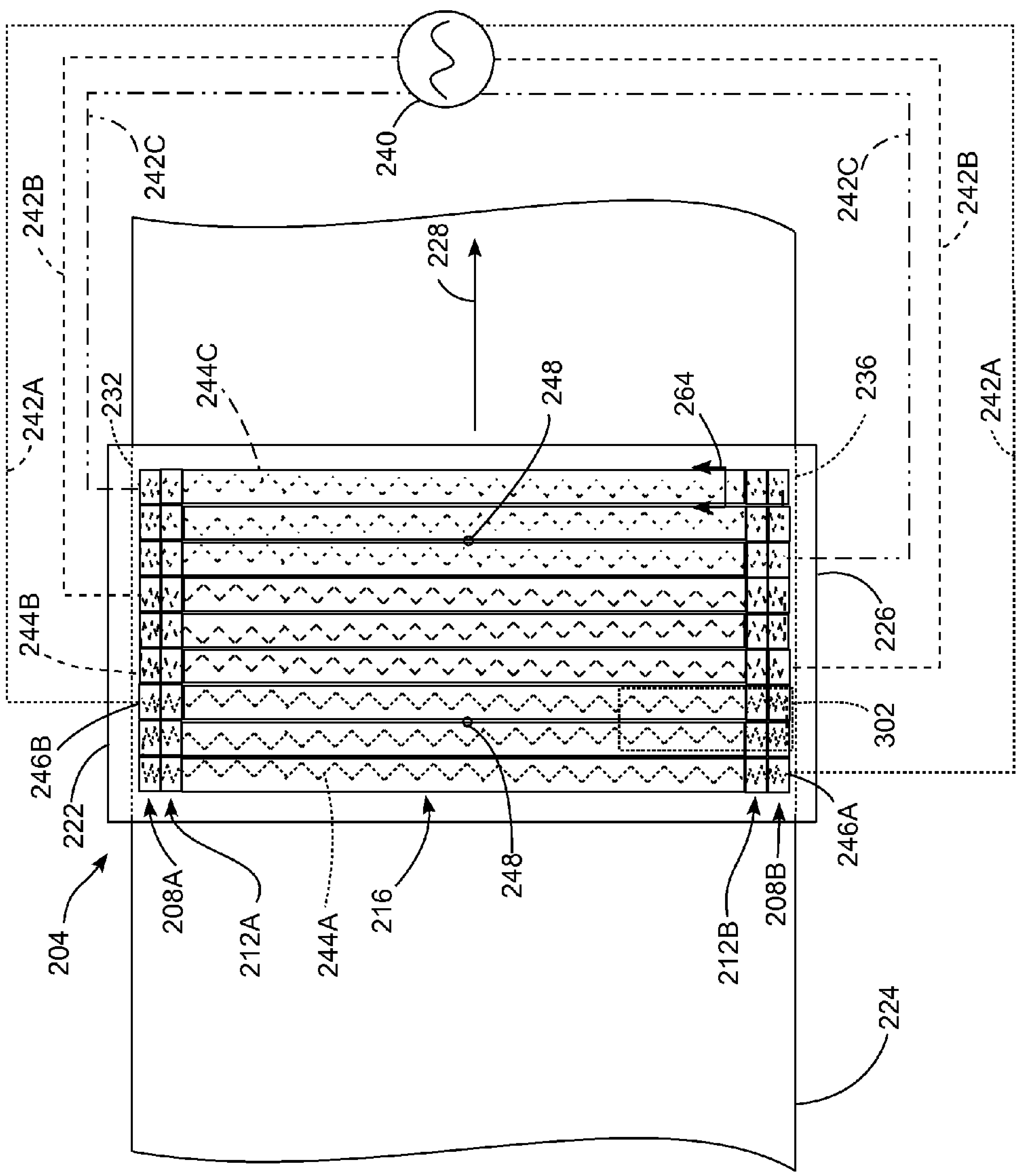

240
242A
242B
242C
228
244C
232
248
264
236
226
244B
246B
222
204
208A
212A
244A
216
212B
208B
246A
302
224

FIG. 2

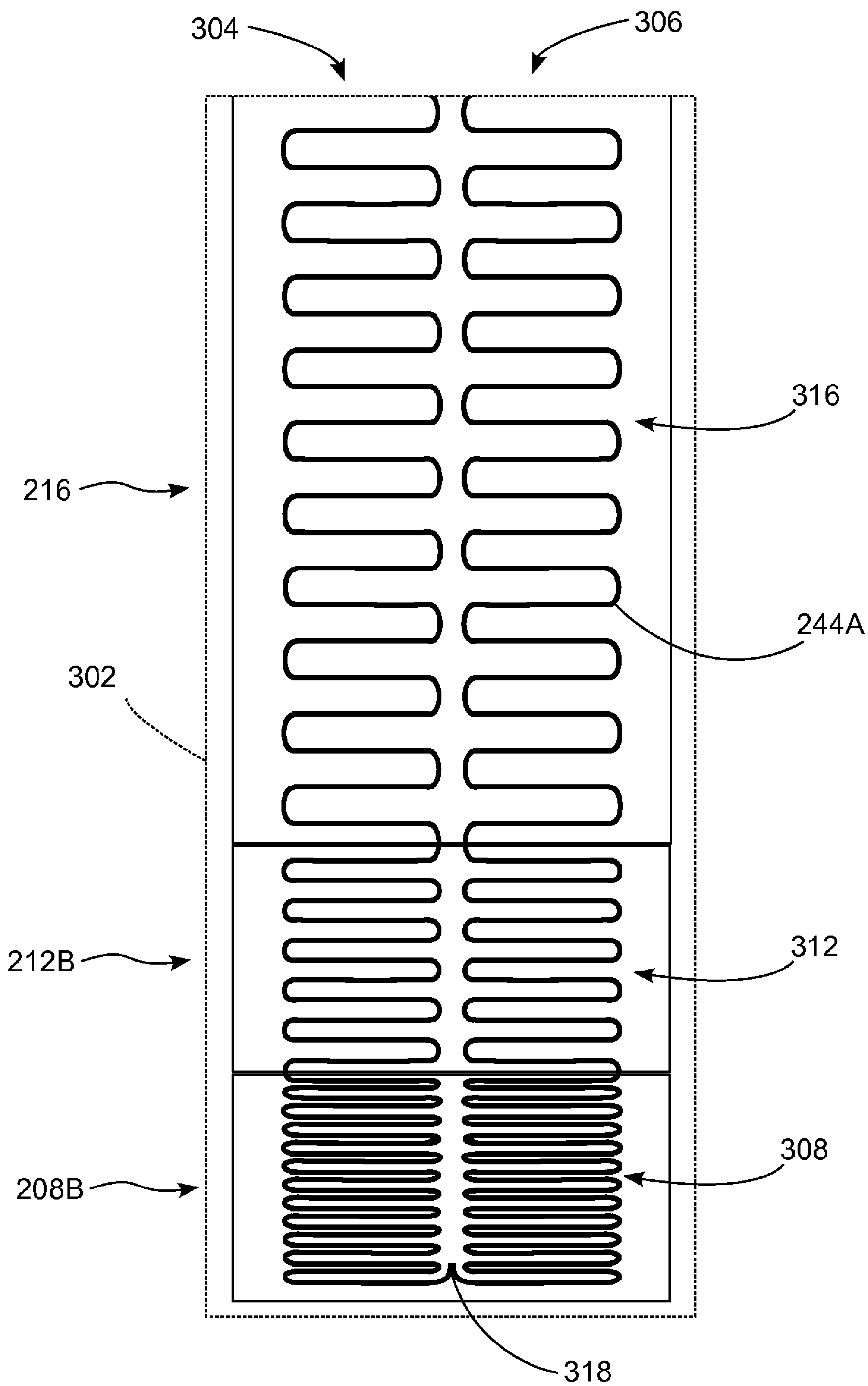


FIG. 3

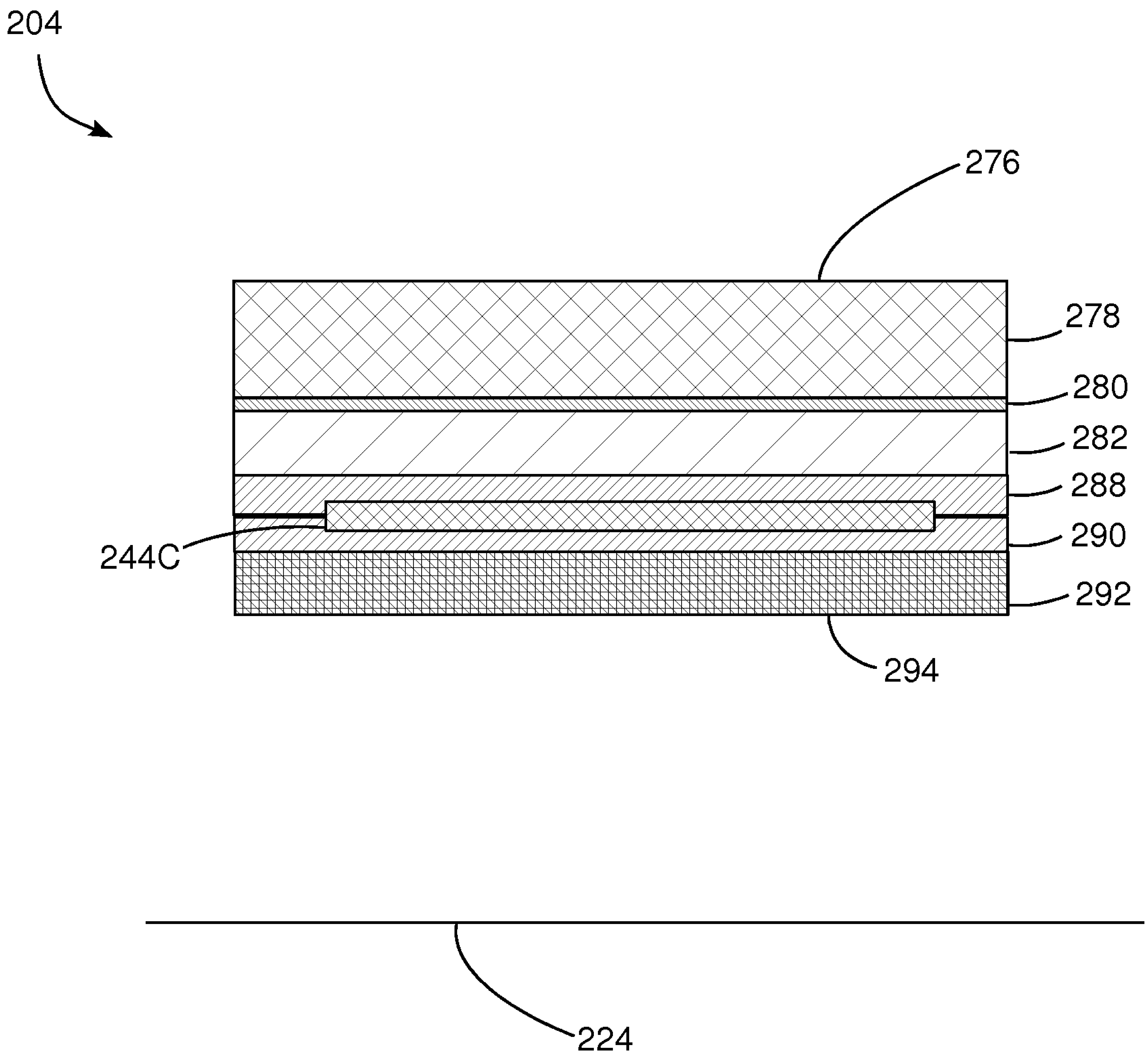


FIG. 4

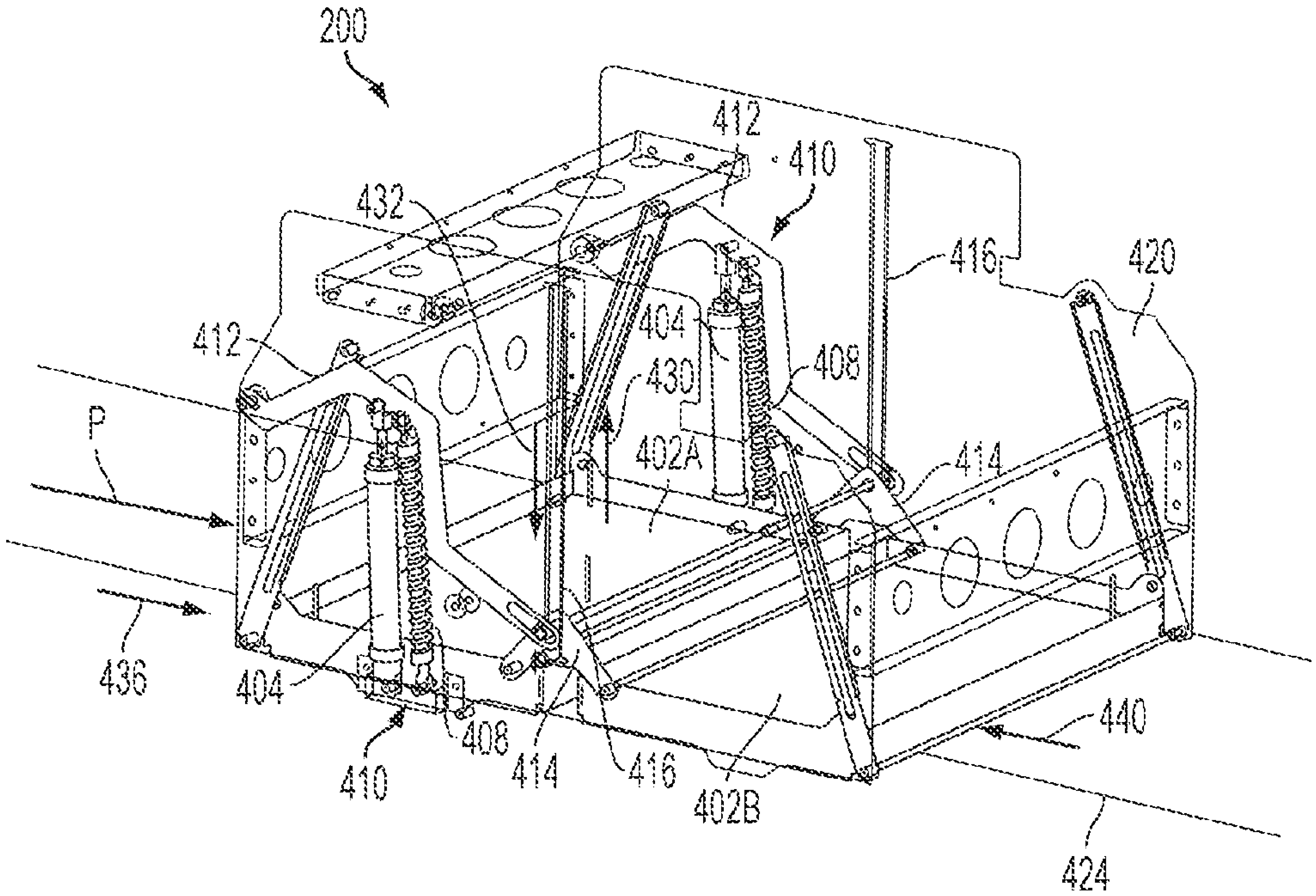

200
412
410
432
416
420
412
404
408
430
402A
414
P
436
404
408
410
414
416
402B
440
424

FIG. 5

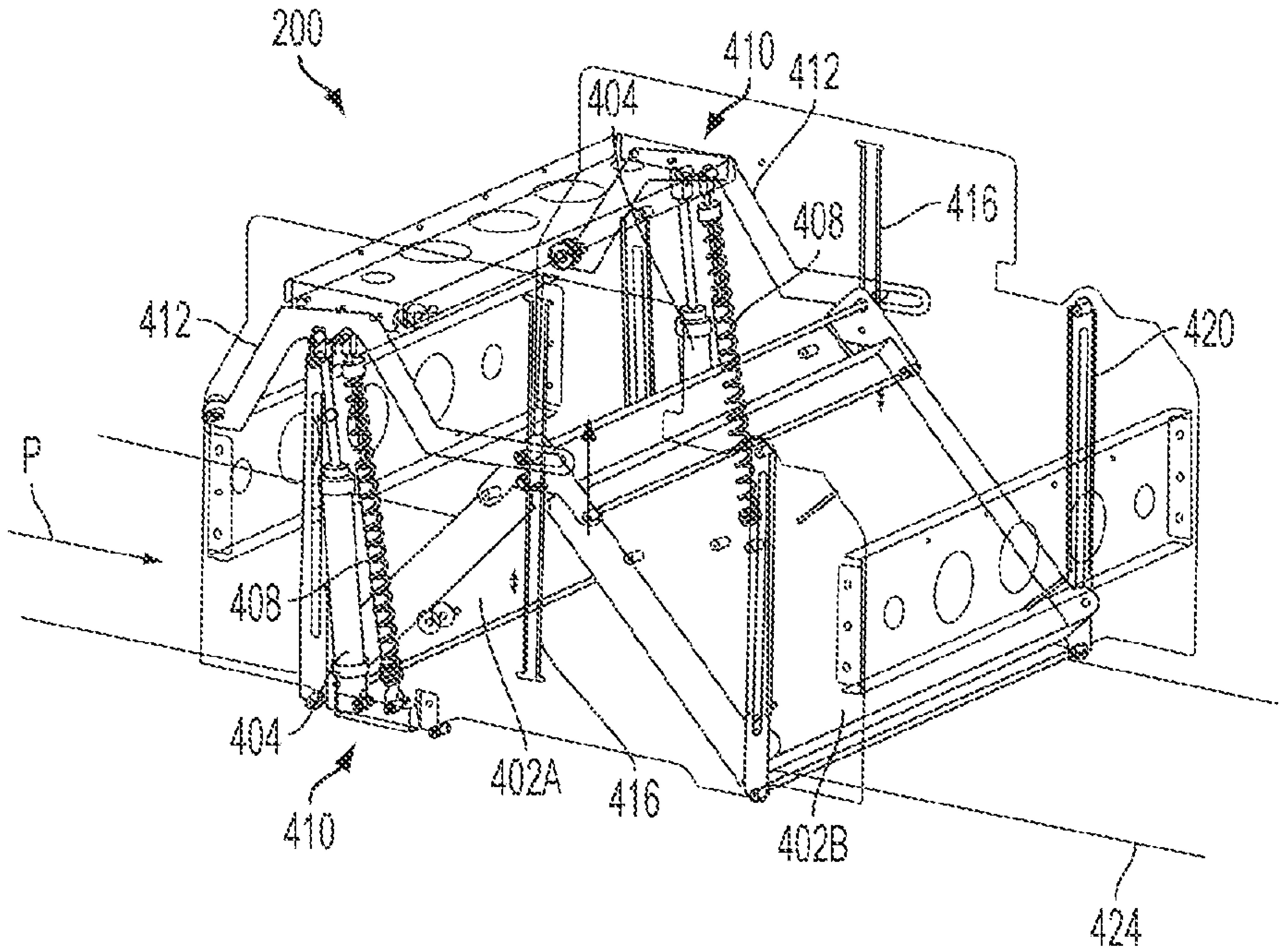


FIG. 6

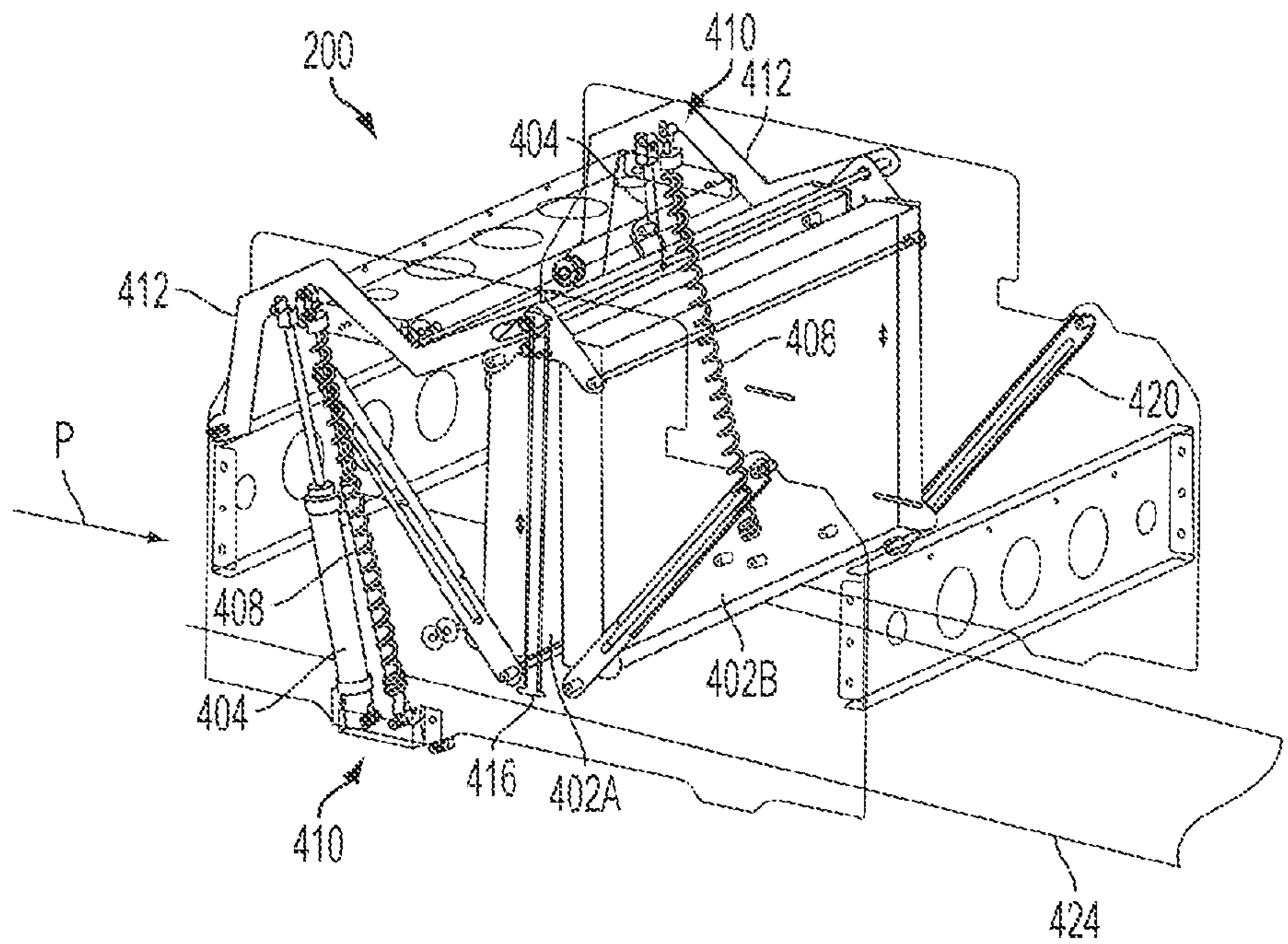


FIG. 7

RADIANT HEATER FOR PRINT MEDIA

TECHNICAL FIELD

This disclosure relates generally to imaging devices that print images on media, and, more particularly, to heaters used to condition the media during printing operations.

BACKGROUND

In general, inkjet printing machines or printers include at least one printhead unit that ejects drops of liquid ink onto recording media or an imaging member for later transfer to media. Different types of ink may be used in inkjet printers. In one type of inkjet printer, phase change inks are used. Phase change inks remain in the solid phase at ambient temperature, but transition to a liquid phase at an elevated temperature. The printhead unit ejects molten ink supplied to the unit onto media or an imaging member. Once the ejected ink is on media, the ink droplets quickly solidify.

The media used in both direct and offset printers may be in sheet or web form. A media sheet printer typically includes a supply drawer that houses a stack of media sheets. A feeder removes a sheet of media from the supply and directs the sheet along a feed path past a printhead so the printhead ejects ink directly onto the sheet. In offset sheet printers, a media sheet travels along the feed path to a nip formed between the rotating imaging member and a transfix roller. The pressure and heat in the nip transfer the ink image from the imaging member to the media. In a web printer, a continuous supply of media, typically provided in a media roll, is entrained onto rollers that are driven by motors. The motors and rollers pull the web from the supply roll through the printer to a take-up roll. As the media web passes through a print zone opposite the printhead or heads of the printer, the printheads eject ink onto the web. Along the feed path, tension bars or other rollers remove slack from the web so the web remains taut without breaking.

Regardless of the type of media used, media heating helps transfer the ink more efficiently to the recording media. In web-fed printers, media heaters typically comprise one or more radiant heaters that are positioned along the media pathway. These heaters raise the temperature of the moving web. Adjusting the power supplied to the heaters controls the output of the radiant heaters. The printing system typically includes a thermal sensor positioned adjacent the media pathway to detect the temperature of the moving web and provide the detected temperatures to a controller. The controller may compare the detected temperatures to temperature thresholds to adjust the power provided to the heaters to maintain the temperature of the media web in appropriate temperature ranges at different locations along the feed path.

Existing radiant heaters used in printers generate heat using high-temperature lamps with one typical lamp having a filament configured to heat to 1200° C. with a surface temperature of 800° C. In operation, these lamps emit radiant energy with a range of wavelengths including portions of the visible spectrum at approximately 0.7 μm through portions of the infrared spectrum at 1.5 μm to 2.5 μm. Some of these lamps are relatively energy inefficient, and require separate reflector elements to redirect radiant energy toward the print media to bring the print media to an appropriate temperature. The energy consumption of the radiant heaters is one factor affecting the operating cost of the printing device. Thus, improvements to radiant heaters that can heat print media while reducing the power usage of printing devices are desirable.

SUMMARY

In at least one embodiment, a radiant heater for heating a print medium in a printer has been developed. The radiant heater includes a ceramic foam substrate having a first edge and a second edge, an electrical conductor bonded to the ceramic foam substrate, and a cover layer bonded to the electrical conductor. The electrical conductor has a first electrical resistance in a first heating zone formed proximate the first edge and the second edge of the ceramic foam substrate and a second electrical resistance in a second heating zone between the first edge and the second edge to enable radiant energy at a first power density in the first heating zone and radiant energy at a second power density in the second heating zone to be emitted by the cover layer, the first power density being greater than the second power density.

In at least one other embodiment, a solid ink printer has been developed. The printer includes a media handling system configured to transport a continuous media web along a media pathway through the imaging device, the media pathway having a first edge and a second edge, a solid ink printing system positioned along the media pathway, a web heating system positioned along the media pathway, and a web heating controller. The solid ink printing system is configured to print images on the continuous media web moving along the media pathway. The web heating system is positioned along the media pathway at a location that enables the web heating system to heat the continuous media web after the solid ink printing system has printed an image on the continuous media web, the web heating system being configured to heat the continuous media web to a web heating temperature. The web heating system includes at least one radiant heating unit positioned adjacent the media pathway a pair of radiant heaters configured within the housing to emit radiant energy in accordance with a variable radiant power signal. The at least one radiant heating unit includes a housing adjacent to the media pathway. The housing has an opening proximate the media pathway. The pair of radiant heaters are configured to be positioned selectively in the housing to any one of a plurality of positions between and including a fully open position in which the pair of radiant heaters are positioned side by side in the opening of the housing to direct radiant energy towards the media pathway and a retracted position in which the pair of radiant heaters are positioned inside the housing and facing each other, a view factor of the pair of radiant heaters with respect to the media pathway being different for each position in the plurality of positions. Each radiant heater includes an electrical conductor bonded to a substrate, the electrical conductor forming a plurality of heating zones, a panel driver operatively connected to the pair of radiant heaters to enable the pair of radiant heaters to be positioned in at least one of the plurality of positions in response to a variable view factor signal, and at least one temperature sensor configured to detect a temperature of the continuous media web moving along the media pathway and to generate a temperature signal indicative of the detected temperature of the continuous media web. The at least one heating zone is configured to emit radiant energy at a first power density towards the first edge and the second edge of the media pathway, and at least one other heating zone configured to emit radiant energy at a second power density towards a central portion of the media pathway. The web heating controller is operatively connected to the panel driver and configured to generate a selected

radiant power signal and the variable view factor signal for operation of the panel driver to position at least one radiant heater to heat the continuous media web to the web heating temperature. The web heating controller is configured to generate at least one of the radiant power signal signals and the variable view factor signals in accordance with the temperature signal generated by the at least one temperature sensor.

In at least another embodiment, a radiant heater panel has been developed. The radiant heater panel includes an electrical conductor having a first electrical resistance, and a cover layer configured to emit heat generated by an electrical current flowing through the electrical conductor. The emitted heat has a wavelength in a predetermined range.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a phase change imaging device for printing onto a continuous media web.

FIG. **2** is a front view of a radiant heater panel.

FIG. **3** is a plan view illustrating heater element artwork used in the radiant heater panel of FIG. **2**.

FIG. **4** is a cross-sectional view of a portion of the heater panel of FIG. **2**.

FIG. **5** is drawing of a radiant heating unit including two heater panels in a deployed configuration.

FIG. **6** is a drawing of the radiant heating unit of FIG. **5** with the two panels in an intermediate configuration.

FIG. **7** is a drawing of the radiant heating unit of FIG. **5** with the two panels in a retracted configuration.

DETAILED DESCRIPTION

For a general understanding of the environment for the system and method disclosed herein as well as the details for the system and method, the drawings are referenced throughout this document. In the drawings, like reference numerals designate like elements. As used herein the term "printer" refers to any device that is configured to eject a marking agent upon an image receiving member and include photocopiers, facsimile machines, multifunction devices, as well as direct and indirect inkjet printers, laser printers, thermal printers, LED printers, and any imaging device that is configured to form images on a print medium. As used herein, the term "process" direction refers to a direction of travel of an image receiving member, such as an imaging drum or print medium, and the term "cross-process' direction is a direction that is perpendicular to the process direction along the surface of the image receiving member.

The term "artwork" refers to the size, shape, pattern, and arrangement of one or more electrical conductors formed in a heater panel. The electrical conductor generates heat in response to an electrical current flowing through the conductor. The configuration of the artwork may vary in different locations through the heater panel to change the power density of radiant energy emitted from the heater panel at each location. The term "power density" refers to an amount of radiant power emitted from a given area of a heater. For example, a 1 cm^2 section of a heater that emits 10 Watts of power has a power density of 10 watts/cm^2. As used herein, a "view factor" is defined as the proportion of the radiant energy emitted by a radiant heater that reaches a print medium in relation to the total amount of radiant energy emitted by the radiant heater.

As shown in FIG. **1**, the phase change ink printing system includes a web supply and handling system **60**, a printhead assembly **14**, a fixing assembly **50** and a web heating system **100**. The web supply and handling system **60** may include one or more media supply rolls **38** for supplying a media web **20** to the imaging device. The supply and handling system is configured to feed the media web in a known manner along a media pathway in the imaging device through the print zone **18**, and past the web heating system **100**, and fixing assembly **50**. To this end, the supply and handling system may include any suitable device **64**, such as drive rollers, idler rollers, tensioning bars, etc., for moving the media web through the imaging device. The system may include a take-up roll (not shown) for receiving the media web **20** after printing operations have been performed. Alternatively, the media web **20** may be fed to a cutting device (not shown) as is known in the art for cutting the media web into discrete sheets.

The printhead assembly **14** is appropriately supported to eject drops of ink directly onto the media web **20** as the web moves through the print zone **18**. In alternative embodiments, the printhead assembly **14** may be configured to emit drops onto an intermediate transfer member (not shown), such as a drum or belt, for subsequent transfer to the media web. The printhead assembly **14** may be incorporated into either a carriage type printer, a partial width array type printer, or a page-width type printer, and may include one or more printheads. As illustrated, the printhead assembly includes four page-width printheads for printing full color images comprised of the colors cyan, magenta, yellow, and black.

The solid ink supply **24** supplies ink to the printhead assembly. Since the phase change printer **10** is a multicolor device, the ink supply **24** includes four sources **28**, **30**, **32**, **34**, representing four different colors CYMK (cyan, yellow, magenta, black) of phase change ink solid ink. Alternative embodiments of the printing system **10** may be configured to print ink having a single color, or to print various ink colors other than the CYMK colors, including spot colors and clear inks. The phase change ink system **24** also includes a solid phase change ink melting and control assembly or apparatus (not shown) for melting or phase changing the solid form of the phase change ink into a liquid form, and then supplying the liquid ink to the printhead assembly **14**.

Once the drops of ejected ink form an image on the moving web, a fixing assembly **50** fixes the ink image to the web as the web passes through the assembly **50**. In the embodiment of FIG. **1**, the fixing assembly **50** comprises at least one pair of fixing rollers **54** that are positioned in relation to each other to form a nip through which the media web is fed. The pressure in the nip presses the ink drops into the media web and spreads the ink on the web. Although the fixing assembly **50** is depicted as a pair of fixing rollers, the fixing assembly may be any suitable type of device or apparatus, as is known in the art, which is capable of fixing the image to the web.

A controller **40** operates and controls the various subsystems, components and functions of the printer **10**. The controller **40** may be implemented as hardware, software, firmware or any combination thereof. In one embodiment, the controller **40** comprises a self-contained, microcomputer having a central processor unit (not shown) and electronic storage (not shown). The electronic storage may store data necessary for the controller such as, for example, the image data, component control protocols, etc. The electronic storage may be a non-volatile memory such as a read only memory (ROM) or a programmable non-volatile memory such as an EEPROM or flash memory. Of course, the electronic storage may be incorporated into the inkjet printer, or may be externally located. The controller **100** is configured to orchestrate the production of printed or rendered images in accordance with image data received from the image data source (not shown). The image data source may be any one of a number of different sources, such as a scanner, a digital copier, a facsimile device, etc. Pixel placement control is exercised relative to the media web **20** in accordance with the print data, thus, forming desired images per the print data as the media web is moved through the print zone.

The web heating system **100** comprises one or more radiant heating units **200** that direct radiant energy onto the web **20**. The media web absorbs the radiant energy emitted from the units **200** at a color temperature suitable for heating the chosen media type, including a 3.0-4.0 um range for paper. Radiant heating units **200** may be positioned anywhere along the media pathway for emitting radiant energy toward the media web. In the embodiment of FIG. **1**, radiant heating units **200** are positioned downstream from the printhead assembly **14** in order to heat the media web **20** prior to fixing the image to the web at the fixing assembly **50**. Mid-heating is a term that describes this type of heating. In other embodiments, radiant heating units **200** may also be positioned to heat the media web prior to reaching the print zone (preheating) and/or downstream from the printhead assembly (post-heating). Any suitable number of radiant heating units may be employed. The web heating system **100** in the depicted embodiment includes three radiant heating units **200** positioned upstream from the printhead assembly that preheat the media web prior to printing and two radiant heating units successively positioned thereafter that heat a front side F of the media web **20**. The web heating system **100** also includes another radiant heating unit that is positioned to heat the backside B of the media web.

In operation, web heating system **100** may heat the media web to any suitable temperature depending upon a number of factors including web speed, web type, ink type, position along the media pathway, etc. For example, when heating the media web, the web heating system may be configured to heat the media web and ink layers to approximately 65 to 70 degrees C. prior to fixing ink images to the web. The web heating system may include one or more noncontact IR temperature sensors **108** as known in the art for measuring the temperature of the moving web **20** at one or more locations associated with the web. Temperature sensors **108** may be non-contact type sensors, such as thermopile or similar IR sensors. In one embodiment, a temperature sensor **108**A that is provided along the media pathway upstream from the radiant heating units **200** of the web heating system detects the temperature of the web prior to the web passing the radiant heating units. Another temperature sensor **108**B may also be provided along the media pathway downstream from the radiant heating units **200** to detect the temperature of the web after the heating units heat the web. Each of the temperature sensors **108**A and **108**B may measure the temperature of the media web at various positions in the cross-process direction. These temperature measurements enable the heating controller **110** to identify whether portions of the web are inside or outside of the operational temperature range. In any case, the temperature sensors **108** are operable to relay signals indicative of the one or more measured temperatures to the web heating controller **110**. Knowing temperatures before and after the heating unit enables the controller to adjust the view factor angle as the web passes the heating units **200** to control the exit paper temperature accurately.

Once the heater units have reached temperatures that are sufficient to heat print media, a relatively significant delay may occur between an adjustment of electrical power supplied to the panels and a corresponding change in the radiant power output of the panels. The web heating system **100** of the present disclosure includes a dual gain control system that regulates the radiant output of the panels by adjusting the delivery of electrical power to the panels (low gain control). The system **100** also controls the amount of radiant energy that reaches the media web from the panels by varying the view factor of the panels relative to the media web (high gain control). As described below, the view factor of the radiant panels to the web may be varied by adjusting the distance, angle and/or orientation of the panels of a heating unit with respect to the media web. View factor adjustments, thus, involve physical movement of the panels with respect to the media web. Therefore, depending on the method of moving the panels, view factor adjustments may be performed relatively quickly to facilitate rapid adjustments of the amount of radiant energy that reaches the media web.

Another development that facilitates the delivery of heat to a web is the construction of a heater panel that generates heat having a particular wavelength. FIG. **2** depicts a front view of such a radiant heater **204** that is suitable for use in a radiant heater unit. FIG. **2** depicts radiant heater **204** that is configured to radiate heat onto a media web **224**. The example embodiment of radiant heater **204** is electrically connected to a three-phase electrical power source **240**. The radiant heater **204** includes three different electrical conductors, shown schematically as conductors **244**A-**244**C, that generate heat in response to electrical current from one of the phases in the three phase power source **240** flowing through each conductor. The conductors **244**A-**244**C may also be referred to as heating elements. Each of the conductors **244**A-**244**C is electrically connected to one phase of the three-phase power supply **240** through electrical leads **242**A-**242**C, respectively. Using conductor **244**A as an example, the conductor is depicted as a line that undulates across a width of the radiant heater **204** between connectors **246**A and **246**B that couple the conductor **244**A to the electrical leads **242**A. The conductor **244**A traverses the width of the heater **204** three times between the connectors **246**A and **246**B. Conductors **244**B and **244**C are configured in a substantially identical fashion to their respective connectors in radiant heater **204**.

Referring to FIG. **2** and FIG. **3**, radiant heater **204** is configured to vary the heat generated by the heater in different heating zones arranged in the heater **204**. In the example of FIG. **2**, each of the electrical conductors **244**A-**244**C passes through heating zones **208**A, **208**B, **212**A, **212**B, and **216**. The electrical resistance of each of the electrical conductors **244**A-**244**C is determined, at least in part, by the number of bends in the conductor in each heating zone. The electrical power source **240** applies an electrical current through each of the conductors **244**A-**244**C to enable the conductors to emit radiant energy at different predetermined power densities in the different heating zones.

The heating zones **208**A, **208**B, **212**A, **212**B, and **216** are arranged as seen in FIG. **2** to enable the heater **204** to heat the media web **224** in a more uniform manner. When heated by conventional media heaters, the areas of the media web **224** near the outside edges **232** and **236** to cool more quickly than areas near the center of the media web **224**. Large differences in web temperature near the edges of the web may result in gloss image changes near the edge of the media, which may result in negative effects on image quality. To address the uneven web temperature, the shape and configuration of the conductors **244**A-**244**C are varied in the different heating zones **208**A, **208**B, **212**A, **212**B, and **216** to enable the radiant heater to radiate heat at a selected power density in each heating zone. The number of bends in the electrical conductor provided by the artwork configuration of the electrical conductor in each heating zone produces different electrical resistances in the conductor at the different zones in the heater panel. Specifically, the power densities in the outer zones **208**A and **208**B are higher than the power densities produced in zones **212**A and **212**B, which are greater than the power density produced in zone **216**. Consequently, the heater watt density (flux) is increased near the edges and varies the amount of heat generated in different sections of the heater to address losses that may occur at different areas of the material being heated.

In FIG. **2**, the power densities of the heating zones **208**A-**208**B and **212**A-**212**B enable these zones to deliver an amount of radiant energy to portions of the print medium near either edge of the print medium in the cross-process direction sufficient to heat those portions of the media to a temperature within an operating temperature range. The portions of the continuous media **224** web near edges **232** and **236** radiate heat more quickly than the central portions of the media web passing over heater zone **216**, and therefore tend to have lower temperatures than the central portions of the media web. The power density of radiant energy delivered to the edges of the print medium **224** enables the temperature over the width of the print medium **224** to be more uniform, with one embodiment maintaining a temperature range of 65° C. to 70° C. across the width of the print medium **224**. The higher power density also reduces the effects of convection buoyancy losses and view factor losses at the edges of the print medium.

As described above, the power density of heat emitted by the conductor in each heating zone is determined by the artwork of the electrically conductive heating element in each heating zone. FIG. **2** includes an area **302** around conductor **244**A that is depicted in more detail in FIG. **3**. As described below, the radiant heater **204** is formed from a plurality of layers, and FIG. **3** depicts only the configuration of the conductor **244**A through heating zones **208**B, **212**B and **216** for clarity.

In FIG. **3**, conductor **244**A is arranged in a sinusoidal pattern extending through the heating zones **208**B, **212**B, and **216**. The pattern in the conductor **244**A presents minor images **304** and **306** of the conductor that are electrically connected at juncture **318**. Section **308** of the conductor **244**A has the densest arrangement of sinusoidal traces in the heating zone **208**B. The bends in this dense arrangement of the conductor **244**A increases the electrical resistance of the conductor in this area, which enables the conductor section **308** to emit a larger portion of heat per unit area than the other heating zones in which the conductor has fewer turns and/or narrower traces.

The artwork of the conductor **244**A in the heating zone **212**B is arranged with sinusoidal traces having a lower density, and a correspondingly lower power density in the heating zone **212**B. In the configuration of FIG. **3**, the conductor section **308** has a higher electrical resistance than conductor section **312**. Heating zones **208**A and **212**A are configured in a substantially identical manner to heating zones **208**B and **212**B, respectively.

Heating zone **216** includes conductor section **316**, which has the lowest relative density of sinusoidal traces, and the corresponding lowest power density. Conductor section **316** also has a lower electrical resistance per unit of length than either conductor section **308** or **312**, but a greater overall electrical resistance because the conductor length is longer in this section. The reader should note that while heating zone **216** has the lowest power density of the heating zones depicted in FIG. **3**, the total level of radiant power (watts) that heating zone **216** emits may be larger than heating zones **208**B and **212**B due to the larger size of the heating zone **216**.

The arrangement of conductor **244**A seen in FIG. **3** is illustrative of one configuration of an electrical conductor in the radiant heater **204**, but other configurations are used in other embodiments. For example, in other embodiments, the conductor is arranged in a variety of different repeating patterns through each heating zone, including squared, sawtoothed, and crossing patterns. Any arrangement of the conductor that generates heat with an appropriate power density may be used. Additionally, while conductor **244**A is arranged differently in three distinct heating zones in FIG. **3**, other embodiments have more or fewer heating zones. In another embodiment, the conductor **244**A is arranged with a continuously varying artwork pattern that generates a correspondingly continuous power density gradient across the width of the radiant heater.

In one operational configuration, three-phase power source **240** supplies a one phase of a three-phase 480V electrical signal to each of the conductors **244**A-**244**C. The heating zones **208**A and **208**B have a combined surface area of approximately 29.5 cm^2, and the segments of the electrical conductors **244**A-**244**C in heating zones **208**A and **208**B are configured to have an electrical resistance of 9.2Ω. Heating zones **212**A and **212**B have a combined surface area of approximately 32.6 cm^2 with the segments of the electrical conductors **244**A-**244**C in those zones having a resistance of 8.5Ω. The central heating zone **216** has a surface area of 403.9 cm^2 with the segments of the electrical conductors **244**A-**244**C in those zones having a resistance of 84Ω. Since each of the conductors **244**A-**244**C forms a single series circuit with the power source **240**, heating zones **208**A-**208**B emit a total of 142.2 watts of radiant power, heating zones **212**A-**212**B emit a total of 131.8 watts of radiant power, and heating zone **216** emits a total of 1297.7 watts of radiant power. Consequently, heating zones **208**A-**208**B emit radiant energy with a power density of 4.8 watts/cm^2, heating zones **212**A-**212**B have a power density of 4.0 watts/cm^2, and heating zone **216** has a power density of 3.2 watts/cm^2. Thus, in this embodiment, heating zone **216** has the highest total radiant power output, while heating zones **208**A-**208**B that direct radiant energy proximate to the edges of a print media have the highest power density.

The radiant heater **204** in FIG. **2** is formed from multiple layers of material that are formed into a panel. FIG. **4** depicts a cross-sectional view of a portion of the radiant heater panel **204** taken along lines **264** in FIG. **2**. The radiant heater **204** includes a mineral wool backing **278**, aluminum reflector member **280**, ceramic support substrate **282**, the electrically conductive heating element **244**C, and a fiberglass cover layer **292**. A first layer of epoxy **288** bonds the ceramic foam substrate **282** to the heating element **244**C, and a second layer of epoxy **290** bonds the fiberglass cover layer **292** about the heating element **244**C. As seen in FIG. **4**, the epoxy layers **288** and **290** bond to each other and fill in gaps formed around the heating element **244**C. When an electrical current is applied to the heating element **244**C, the heating element heats the fiberglass cover layer **292** and the radiant heater **204** radiates heat toward media web **224**.

Support substrate **282** is embodied here as a ceramic foam panel. Ceramic foam is a porous material with numerous air pockets formed through the ceramic foam to form an efficient thermal insulator. The air in the ceramic foam and the foam itself both have low specific heat and low thermal conductivity. In the embodiment of FIG. **4**, an aluminum heat reflector **280** is positioned next to the ceramic foam layer **282** to reflect heat generated in the radiant heater **204** toward the heater element **244**C, fiberglass cover layer **282**, and media web **224**. The mineral wool layer **278** is a fibrous material that serves as a thermal insulator positioned next to the aluminum reflector **280**. In combination, the reflector plate **280**, ceramic foam layer **282** and mineral wool layer **278** insulate one side of the heating element **244**C to reduce the amount of heat that radiates away from the media web **224**. In the example embodiment of FIG. **4**, the top surface **276** of the mineral wool layer **278** is approximately 400° C. cooler than the bottom surface **294** of the fiberglass cover layer **292** when the radiant panel **204** heats to an operational temperature. The ceramic foam substrate **282**, aluminum reflector **280**, and mineral wool **276** are illustrative of one configuration for containing heat within the panel **204**. Alternative embodiments include different materials and insulator configurations that are suitable for use in the operating temperature range of the radiant heater.

The heating element **244**C generates heat in the radiant heater **204** when an electric current passes through the heating element. Epoxy layer **288** bonds the heating element **244**C to the substrate layer **282**. In the example embodiment of FIG. **4**, the heating element **244**C is formed from a metallic alloy that is commercially available under the Inconel® brand name. Other materials suitable for use as electrically conductive heating elements may be used in alternative radiant heater configurations. As described above, the shape and configuration artwork of the heating element **244**C changes between different heating zones in the radiant heater **204**. In some embodiments, the thickness of the heating element **244**C also varies to adjust the heat output of the heating element in different heating zones within the radiant heater panel **204**.

A fiberglass cover layer **292** is bonded to the heater element **244**C and substrate layer **282** by epoxy later **290**. This fiberglass layer **292** absorbs and radiates the heat generated by the conductors of the heater panel. In one embodiment, the epoxy later **290** permeates a porous fiberglass material to form a fiberglass-epoxy matrix for the fiberglass cover layer **292**. A fiberglass mesh such as a fiberglass scrim cloth is one form of fiberglass that forms a matrix with the epoxy. The fiberglass cover layer **292** emits heat through a bottom surface **294** with wavelengths of greater than 3.0 μm. In the embodiment of FIG. **4**, the majority of the generated heat has a wavelength in the 3.0 μm to 4.0 μm range that corresponds to the infrared portion of the electromagnetic spectrum. Various materials commonly used in print media, such as paper, water, and wax, efficiently absorb wavelengths of heat in the infrared range of the electromagnetic spectrum. In other embodiments, the epoxy layer **290** is formed from a dark or black colored epoxy that permeates the fiberglass cover layer **292** and gives the fiberglass cover layer **292** a dark or black color. The dark or black color promotes emission of radiant heat energy with the selected wavelengths.

The radiant heater **204** emits radiant energy concentrated at wavelengths that heat print media efficiently and selectively concentrate the radiant energy on portions of the print media that lose heat more quickly. Thus, radiant heater **204** heats print media to an operational temperature range more efficiently than previously known heaters, and the radiant heater **204** operates with a lower electrical energy input than previously known heaters since the print medium **224** absorbs a portion of the radiant energy emitted from radiant heater **204** that is sufficient to heat the medium to an operating temperature.

With reference to FIG. **2**, thermocouples **248** are bonded between one of the electrical conductors **244**A, **244**C and the cover layer **292** to generate electrical signals that correspond to the temperature of the heater **204**. In operation, a heater controller monitors the thermocouples **248** to identify the temperature and corresponding radiant power level of the heater **204**. The heater controller increases or decreases the voltage level applied to the heater **204** to increase or decrease, respectively, the total radiant power output of the heater **204**. The variable voltage applied to the panels is a variable radiant power signal, and the heater controller selects different variable voltage levels to apply low gain control to the heater panel. The thermocouples **248** are used in conjunction with various media temperature sensors, such sensors **108**A and **108**B shown in FIG. **1**, to enable this feedback control of the heater.

The configuration of the radiant heater **204** depicted in FIG. **2** is merely exemplary, and alternative heaters may employ greater or fewer heating zones with larger or smaller surface areas, power densities, and total radiant power output levels. Various alternative embodiments of radiant heater **204** include one or more heating zones energized with different electrical currents to produce selected levels of radiant power. Other alternative embodiments form a continuous power density gradient across the radiant heater instead of providing discrete heating zones. While radiant heater **204** is depicted using three electrical conductors that are connected to a three-phase electrical power source, alternative embodiments generate radiant energy using one or more conductors in response to receiving both alternating current (AC) having different phases and direct current (DC) electrical signals.

FIG. **5**-FIG. **7** depict a radiant heating unit **200** with heater panels **402**A and **402**B arranged in three different positions. Radiant heating unit **200** includes two radiant heaters **402**A and **402**B, a panel driver **410**, shown here as actuators **404** and gas springs **408**, a drive link **412**, drive path **416**, and rotatable arms **420**. A print medium, shown here as a continuous media web **424**, travels in a process direction P past the radiant heating unit **200**. The embodiment of radiant heater **204** from FIG. **2** may be used for the radiant heaters **402**A and **402**B, with the heating zones configured to deliver heat to the side edges of the media web **424** being arranged parallel to the process direction P. Drive link **412** includes two arms that are each rotatably engaged to actuator **404** and gas spring **408** at a first end and to a slidable member **414** at a second end. The slidable members **414** engage heaters **402**A and **402**B, and are configured to move along the drive path **416** in directions **432** and **430**. Actuators **404** may be pneumatic, hydraulic, or electromechanical devices configured to move the drive link **412** and slidable members **414** along the drive path **416** in direction **430**. Gas springs **408** are configured to generate a compressing force that urges the drive link **412** along the drive path **416** in direction **432**. Thus, actuators **404** and gas springs **408** apply opposing forces to the drive link **412**, and panel driver **410** may operate the actuators **404** and gas springs **408** to move heaters **402**A and **402**B to various positions with respect to the continuous media web **424**. In the configuration of FIG. **5**, radiant heaters **402**A and **402**B are arranged in parallel to the continuous media web **424**. This configuration produces the maximum view factor for the heater unit **200** with substantially all of the radiant energy emitted from the radiant heaters **402**A and **402**B being directed towards continuous media web **424**.

In operation, heating unit **200** receives variable radiant power signals and variable view factor signals from a controller, such as heater controller **110** described above. The variable view factor signal may be an electrical signal that directs actuators **404** to exert a predetermined amount of force in direction **430**. The predetermined amount of force counteracts the forces exerted by gas springs **408** in direction **432**. In the configuration of FIG. **5**, the variable view factor signal may direct the actuators **404** to exert no force. In the configuration of FIG. **6**, actuators **404** exert a force sufficient to raise drive links **412** to an intermediate position along drive path **416**. The slidable member **414** pulls one end of each radiant heater **402**A and **402**B to the intermediate position. In response to the movement of slidable member **414**, the opposite ends of heaters **402**A and **402**B move with rotatable arms **420** in directions **436** and **440**, respectively.

As seen in FIG. **6**, radiant heaters **402**A and **402**B are positioned at an acute angle with respect to the continuous media web **424**. This angle directs a fraction of the radiant energy emitted towards the media web **424** in the configuration of FIG. **5** away from the media web. This action reduces the view factor presented by the heating unit. In FIG. **7**, the controller operates the actuators to retract the radiant heaters **402**A and **402**B to a position that is substantially perpendicular with respect to continuous media web **424**. In the retracted position the view factor cancels each panels radiant energy allowing the delivered power to be reduced to simmer at roughly 15 to 25% of the actual run power controlled by the thermocouple imbedded in the panel. The simmer power establishes the correct panel temperature prior to unfolding to reduce the time necessary to achieve the correct surface temperature for running. The panel duty cycle is controlled from the IR sensor on the paper during run. The panel device moves to retracted or closed position fast enough to prevent the web from achieving **300**C surface temperature when the web is not moving. Additionally, the rotatable arms **420** enable radiant heaters **402**A and **402**B to slide together in directions **436** and **440**, respectively.

In the configuration of FIG. **7**, a minimal amount of radiant energy reaches the continuous media web **424** as the heater panels **402**A and **402**B shield most of the emitted radiant energy to establish a minimal view factor with respect to the continuous media web **424**. The controller uses the variable view factor signal to operate the actuator **404** in the panel driver **410** to position the radiant heater panels **402**A and **402**B at various intermediate positions between the configurations of FIG. **5** and FIG. **7**. Panel driver **410** is configured to move heater panels between any of the configurations shown in FIG. **5**-FIG. **7**, as well as to various intermediate positions.

The embodiment of heater unit **200** depicted in FIG. **5**-FIG. **7** is illustrative of only one heater unit configuration. Various alternative embodiments may use a single heater panel, or use three or more heater panels in various configurations. Some embodiments may use heaters having different surface areas, heating zones, power outputs, and power densities in a single heater unit. The view factor may be also be adjusted in different ways. In one alternative embodiment, the view factor may be adjusted by moving the heaters in a linear direction to position the panels closer or farther from the media web. In another embodiment, a shielding member may be selectively positioned between a portion of the heaters and the media web to block a portion of the radiant energy from reaching the media web. Alternative mechanical drive units and drive link arrangements known to the art may be used to adjust the positions of the heaters.

It will be appreciated that variants of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems, applications or methods. For example, while the heater panels and radiant heater units depicted above are shown in the context of an inkjet printer, the foregoing heaters are suitable for heating print media to various operating temperatures in various embodiments of printers other than inkjet printers. Various presently unforeseen or unanticipated alternatives, modifications, variations or improvements may be subsequently made by those skilled in the art that are also intended to be encompassed by the following claims.

What is claimed:

1. A radiant heater for heating media in a printer comprising:

a ceramic foam substrate having a first edge and a second edge;

an electrical conductor bonded to the ceramic foam substrate; and

a cover layer bonded to the electrical conductor, the electrical conductor having a first electrical resistance in a first heating zone formed proximate the first edge and the second edge of the ceramic foam substrate and a second electrical resistance in a second heating zone between the first edge and the second edge to enable radiant energy at a first power density in the first heating zone and radiant energy at a second power density in the second heating zone to be emitted by the cover layer, the first power density being greater than the second power density.

2. The radiant heater of claim **1** wherein the electrical conductor has a third electrical resistance in a third heating zone between the first heating zone and the second heating zone to enable radiant energy at a third power density to be emitted by the cover layer in the third heating zone.

3. The radiant heater of claim **1** wherein the cover layer in the first heating zone, the second heating zone, and the third heating zone is configured to emit radiant energy having wavelengths of greater than 3 μm.

4. The radiant heater of claim **1** further comprising:

a temperature sensor configured to generate a temperature measurement of at least one of the first heating zone, second heating zone, and third heating zone.

5. The radiant heater of claim **4** wherein the temperature sensor is a thermocouple positioned in the ceramic foam substrate.

6. The radiant heater of claim **4**, the cover layer further comprising:

a fiberglass mesh; and

an epoxy material between the electrical conductor and the fiberglass mesh to bond the fiberglass mesh to the electrical conductor and to form a fiberglass-epoxy matrix that emits the radiant energy generated by the electrical conductor.

7. A solid ink printer comprising:

a media handling system configured to transport a continuous media web along a media pathway through the imaging device, the media pathway having a first edge and a second edge;

a solid ink printing system positioned along the media pathway, the solid ink printing system being configured to print images on the continuous media web moving along the media pathway;

a web heating system positioned along the media pathway at a location that enables the web heating system to heat the continuous media web after the solid ink printing system has printed an image on the continuous media web, the web heating system being configured to heat the continuous media web to a web heating temperature, the web heating system comprising:

at least one radiant heating unit positioned adjacent the media pathway, the at least one radiant heating unit including:

a housing adjacent to the media pathway, the housing having an opening proximate the media pathway;

a pair of radiant heaters configured within the housing to emit radiant energy in accordance with a variable radiant power signal, the pair of radiant heaters being configured to be positioned selectively in the housing to any one of a plurality of positions between and including a fully open position in which the pair of radiant heaters are positioned side by side in the opening of the housing to direct radiant energy towards the media pathway and a retracted position in which the pair of radiant heaters are positioned inside the housing and facing each other, a view factor of the pair of radiant heaters with respect to the media pathway being different for each position in the plurality of positions, each radiant heater comprising:

an electrical conductor bonded to a substrate, the electrical conductor forming a plurality of heating zones, at least one heating zone is configured to emit radiant energy at a first power density towards the first edge and the second edge of the media pathway, and at least one other heating zone configured to emit radiant energy at a second power density towards a central portion of the media pathway;

a panel driver operatively connected to the pair of radiant heaters to enable the pair of radiant heaters to be positioned in at least one of the plurality of positions in response to a variable view factor signal;

at least one temperature sensor configured to detect a temperature of the continuous media web moving along the media pathway and to generate a temperature signal indicative of the detected temperature of the continuous media web; and

a web heating controller operatively connected to the panel driver and configured to generate a selected radiant power signal and the variable view factor signal for operation of the panel driver to position at least one radiant heater to heat the continuous media web to the web heating temperature, the web heating controller being configured to generate at least one of the radiant power signal signals and the variable view factor signals in accordance with the temperature signal generated by the at least one temperature sensor.

8. The printer of claim **7**, the at least one temperature sensor further comprising:

a first temperature sensor configured to detect a temperature of the continuous media web at a position prior to the continuous media web reaching the pair of radiant heaters and to generate a first temperature signal indicative of the detected temperature of the continuous media web before the continuous media web reaches the pair of radiant heaters; and

a second temperature sensor configured to detect a temperature of the media web at a position after the pair of radiant heaters have heated the continuous media web and to generate a second temperature signal indicative of the detected temperature of the continuous media web after the continuous media web passes the pair of radiant heaters.

9. The printer of claim **8**, the web heating controller being configured to generate radiant power signal signals and variable view factor signals for at least one of the radiant heaters in accordance with the first and the second temperature signals.

10. The printer of claim **9**, the web heating controller being configured to generate radiant power signals for the pair of the radiant heaters to operate the pair of radiant heaters to emit radiant energy to heat the continuous media web moving along the media pathway to the web heating temperature; and

the web heating controller being configured to generate at least one variable view factor signal to adjust the view factor of the pair of radiant heaters to compensate for deviations of the detected temperature from the web heating temperature.

11. The printer of claim **7**, wherein the first power density of radiant energy is greater than the second power density of radiant energy.

12. The printer of claim **7**, wherein each heating zone emits radiant energy having wavelengths greater than 3 μm.

13. The printer of claim **7**, the substrate further comprising:

a ceramic foam layer bonded to the electrical conductor;

an aluminum reflector positioned on a side of the ceramic foam layer opposite the electrical conductor; and

a mineral wool layer positioned on the aluminum reflector.

14. The printer of claim **13**, the radiant heater further comprising:

a cover layer bonded to the electrical conductor, the electrical conductor having a first electrical resistance in a first heating zone formed proximate a first edge and a second edge of the ceramic foam layer and a second electrical resistance in a second heating zone between the first edge and the second edge of the ceramic foam layer to enable radiant energy at the first power density in the first heating zone and radiant energy at a second power density in the second heating zone to be emitted by the cover layer, the first power density being greater than the second power density.

15. The printer of claim **14** wherein the electrical conductor has a third electrical resistance in a third heating zone between the first heating zone and the second heating zone to enable radiant energy at a third power density to be emitted by the cover layer in the third heating zone.

16. The printer of claim **15** wherein the cover layer in the first heating zone, the second heating zone, and the third heating zone is configured to emit radiant energy having wavelengths of greater than 3 μm.

17. The printer of claim **15** further comprising:

a temperature sensor configured to generate a temperature measurement of at least one of the first heating zone, second heating zone, and third heating zone.

18. The printer of claim **17** wherein the temperature sensor is a thermocouple positioned between the electrical conductor and the cover layer.

19. A radiant heater comprising:

an electrical conductor having a first electrical resistance; and

a cover layer essentially comprised of a fiberglass-epoxy matrix, the cover layer being configured to emit heat generated by an electrical current flowing through the electrical conductor, the emitted heat having a wavelength in a predetermined range.

20. The radiant heater of claim **19** wherein the predetermined range corresponds to a range for infrared electromagnetic radiation.

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